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(54) **TRANSCODING OF COMMUNICATION WITH PERSONAL HEALTH DEVICES**

(71) Applicant: **Signove Tecnologia S/A**, Campina Grande, Paraiba (BR)

(72) Inventors: **Elvis Pfützenreuter**, Prata (BR); **José Luis do Nascimento**, Campina Grande (BR); **Mateus Assis Máximo de Lima**, Campina Grande (BR)

(73) Assignee: **Signove Tecnologia S/A**, Campina Grande, Paraiba (BR)

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H04L 29/08 (2006.01)
G06F 19/00 (2011.01)

(52) **U.S. Cl.**

CPC ***H04L 67/08*** (2013.01); ***H04L 67/2823*** (2013.01); ***H04L 67/2861*** (2013.01); *G06F 19/3418* (2013.01)

(58) **Field of Classification Search**

None
See application file for complete search history.

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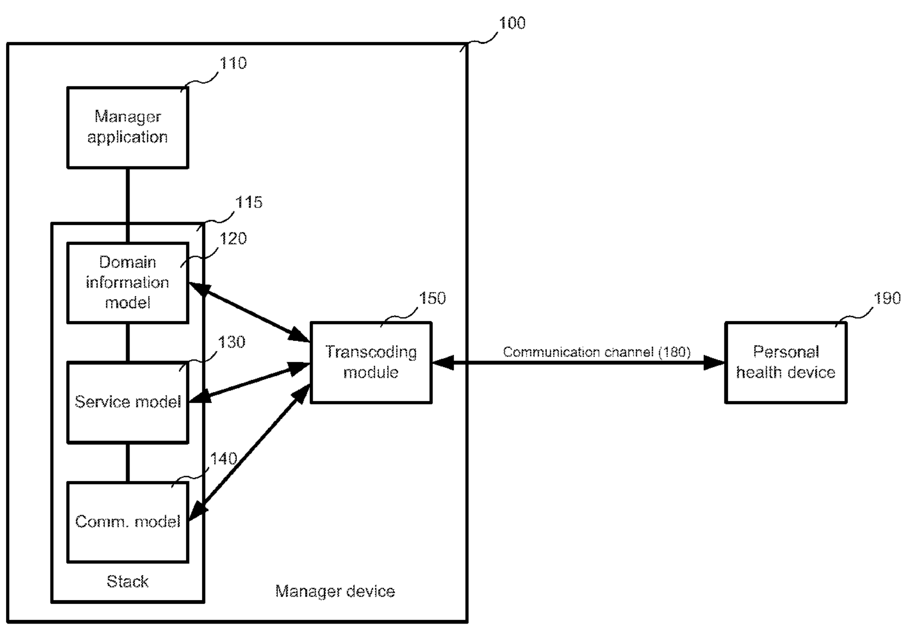
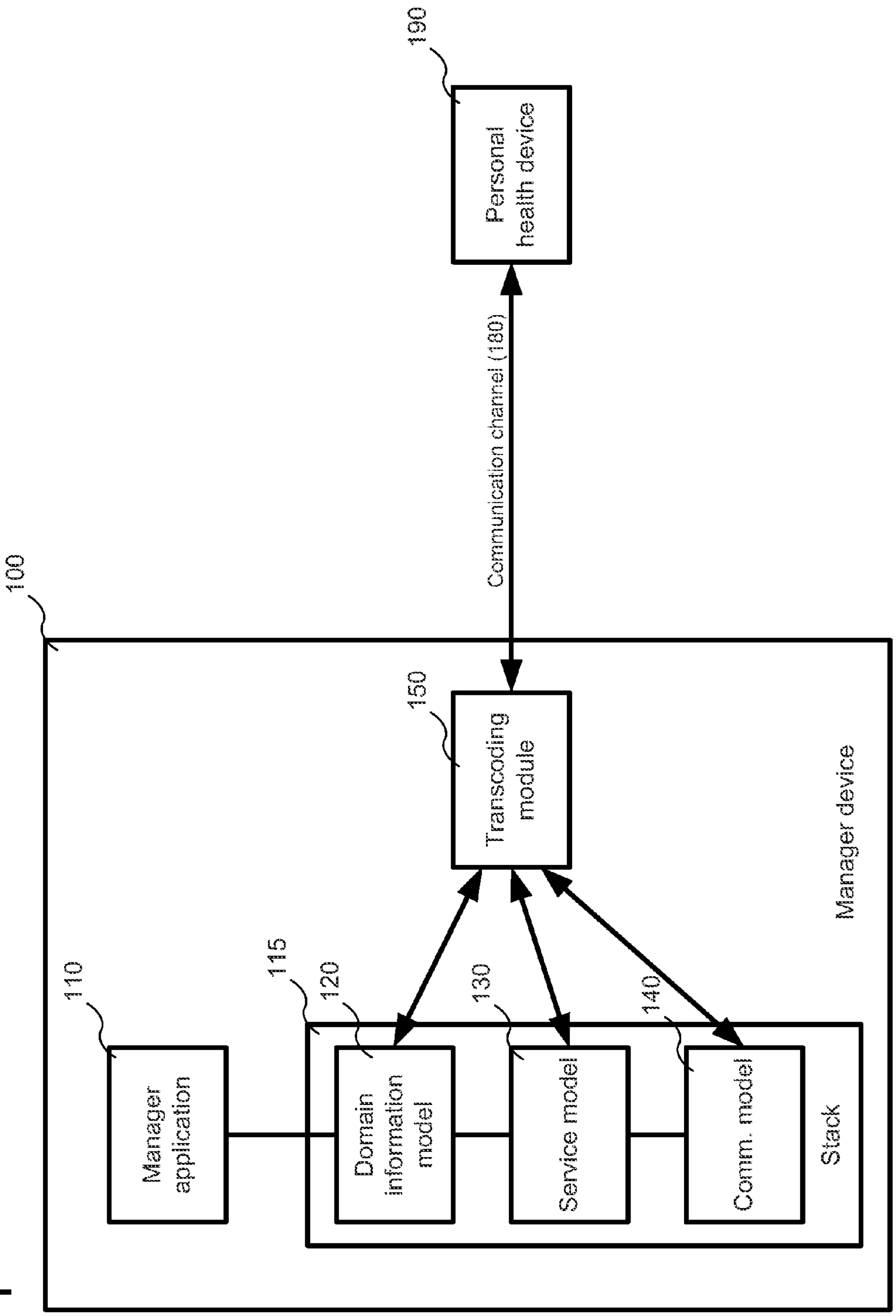
Primary Examiner — Duc Duong
(74) *Attorney, Agent, or Firm* — Schwabe, Williamson & Wyatt, P.C.

(57) **ABSTRACT**

In embodiments, devices, computer-readable media, and methods for personal health device transcoding may be described. A transcoding module may serve as an interface between a manager device implementing an IEEE 11073-20601 ("IEEE 11073") standard and a personal health device that does not implement the standard. The transcoding module may be configured to interact with one or more models of an IEEE 11073 stack implemented by the manager device. The transcoding device may be configured to redirect requests from the models and emulate responses from the personal health device such that the personal health device appears, to the manager device, to implement the IEEE 11073 standard. The transcoding module may perform the emulation asynchronously, through transcoding of communications with the personal health device, or may synchronously generate responses on behalf of the personal health device. Other embodiments may be described.

21 Claims, 8 Drawing Sheets





190
Personal health device
Communication channel (180)
100
150
Transcoding module
Manager device
110
Manager application
115
120
Domain information model
130
Service model
140
Comm. model
Stack

FIG. 1

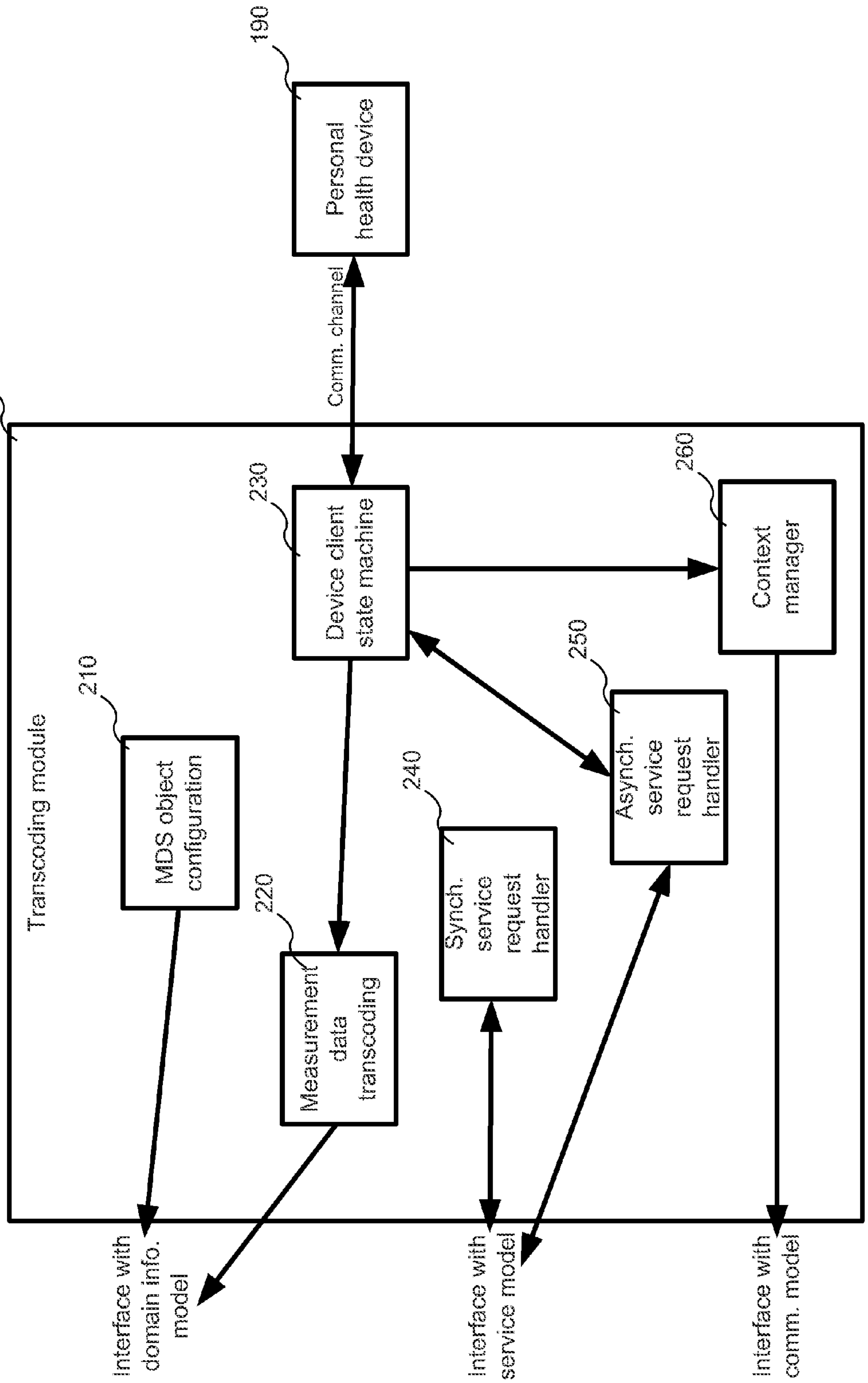

190
Personal health device
Comm. channel
150
Transcoding module
230
Device client state machine
260
Context manager
210
MDS object configuration
250
Asynch. service request handler
240
Synch. service request handler
220
Measurement data transcoding
Interface with domain info. model
Interface with service model
Interface with comm. model

FIG. 2

FIG. 3

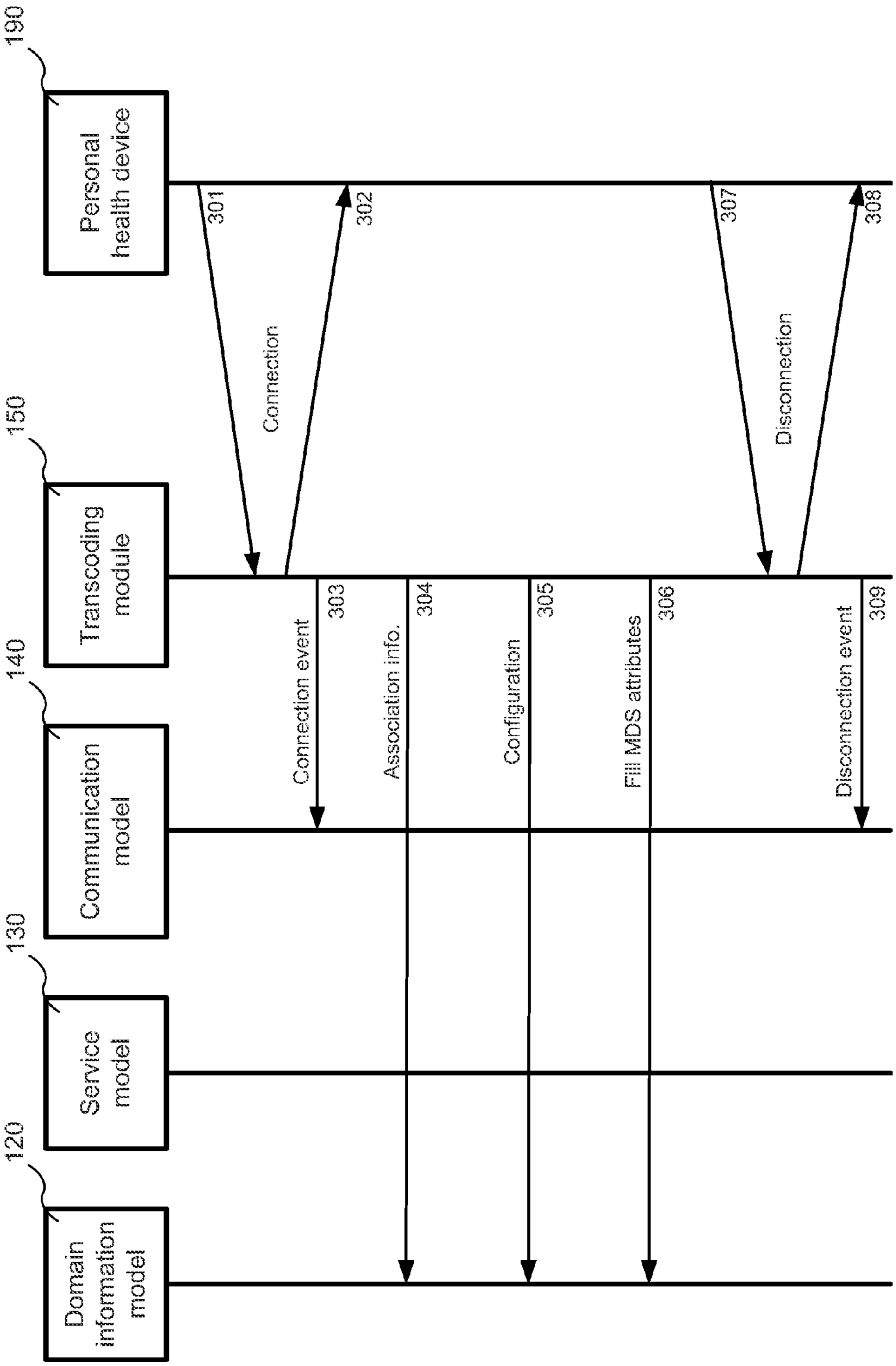
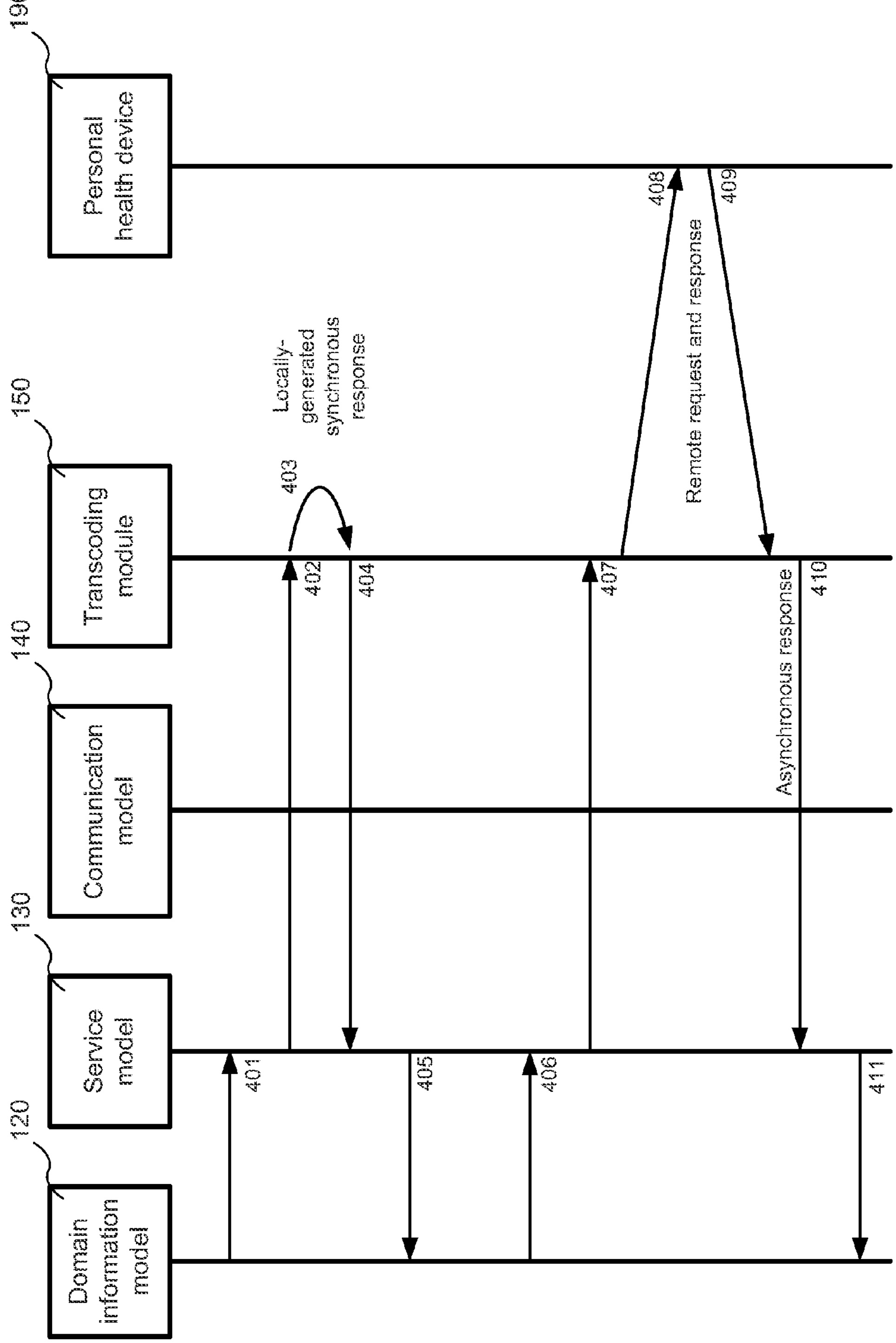

190
Personal health device
150
Transcoding module
140
Communication model
130
Service model
120
Domain information model
301
302
Connection
307
308
Disconnection
303
Connection event
304
Association info.
305
Configuration
306
Fill MDS attributes
309
Disconnection event

FIG. 4



190
Personal health device
150
Transcoding module
140
Communication model
130
Service model
120
Domain information model
Locally-generated synchronous response
Remote request and response
Asynchronous response
401
402
403
404
405
406
407
408
409
410
411

FIG. 5

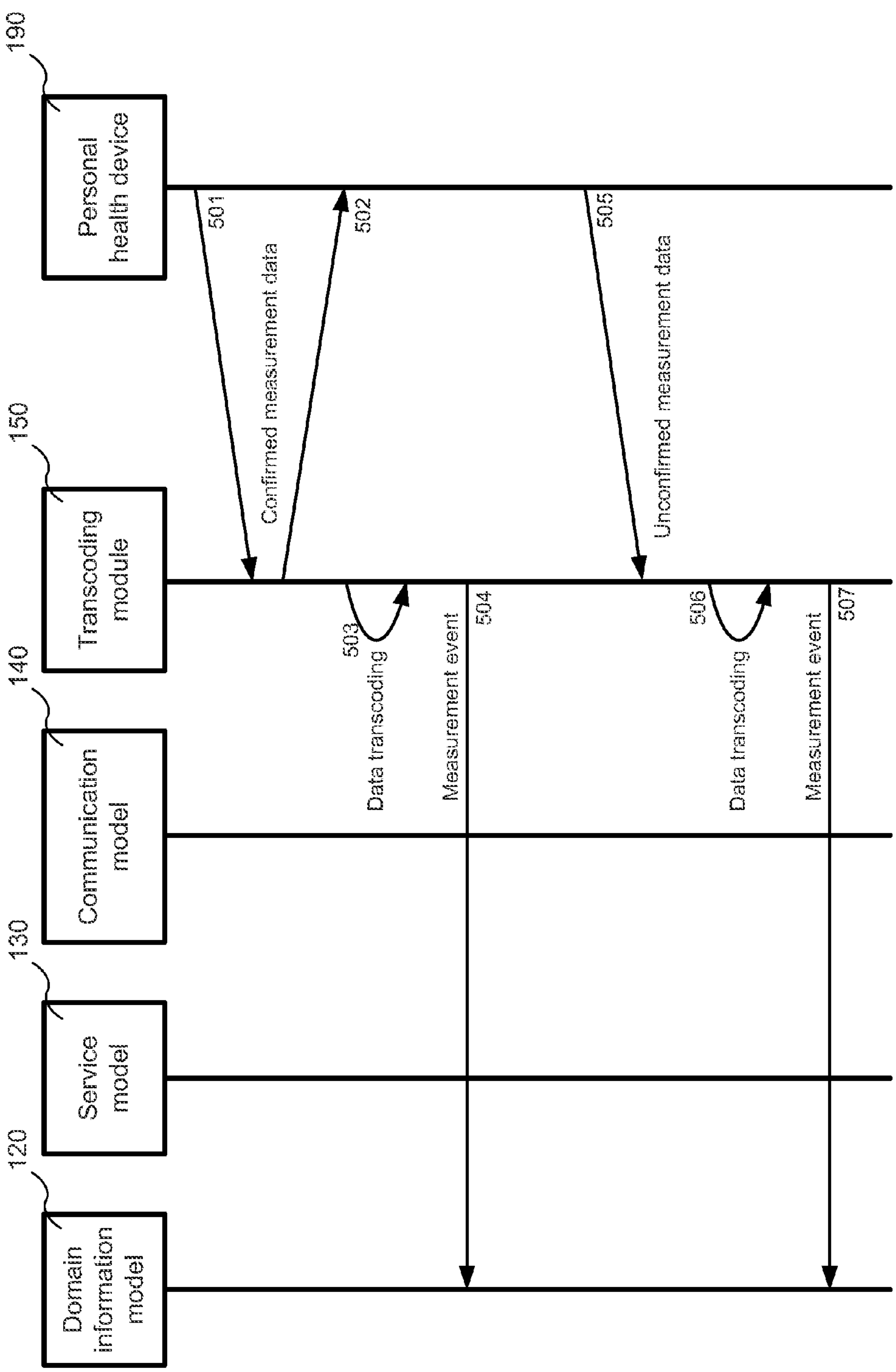
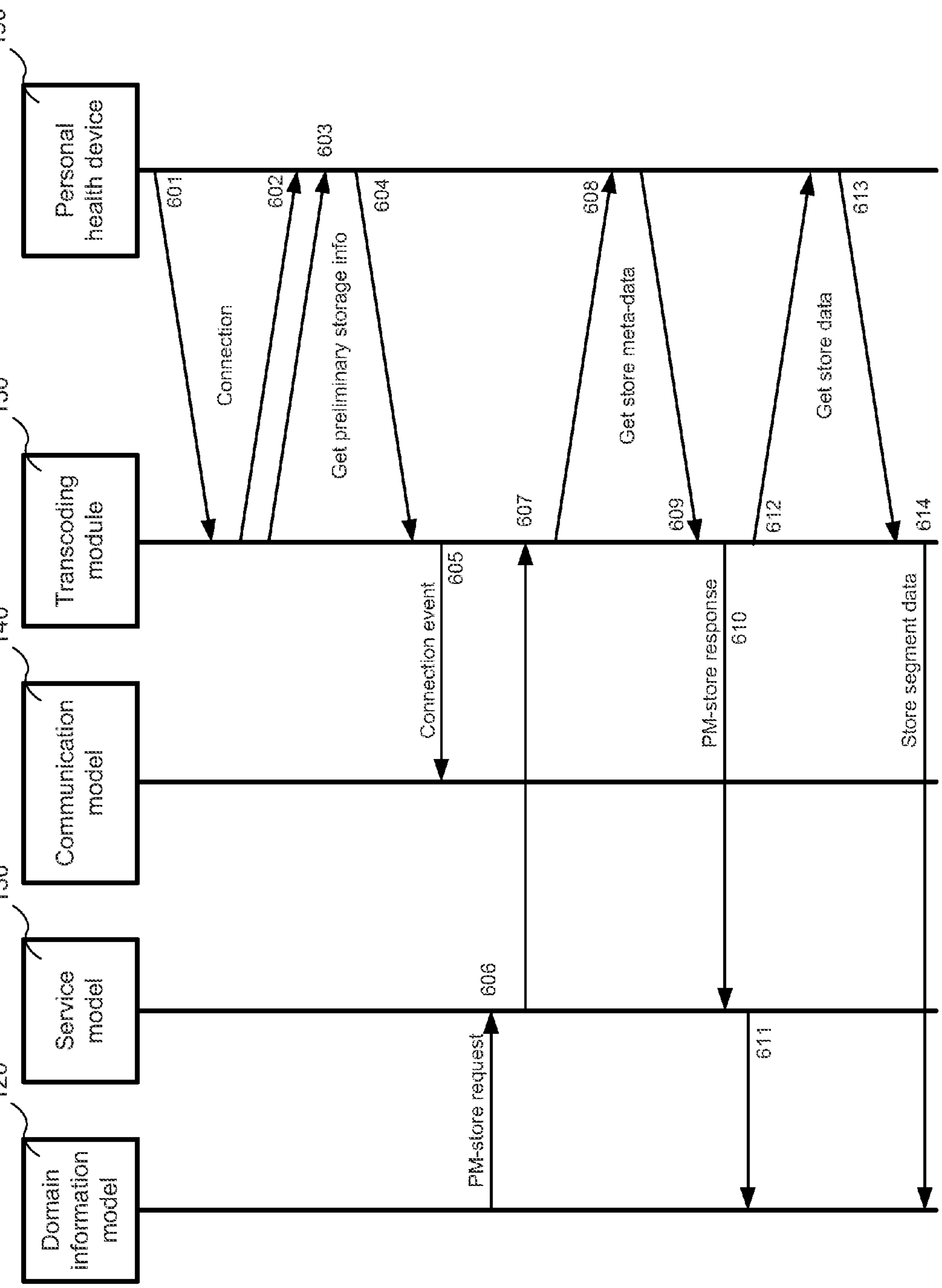

190
Personal health device
150
Transcoding module
140
Communication model
130
Service model
120
Domain information model
501
502
Confirmed measurement data
505
Unconfirmed measurement data
503
Data transcoding
504
Measurement event
506
Data transcoding
507
Measurement event

FIG. 6



190
Personal health device
150
Transcoding module
140
Communication model
130
Service model
120
Domain information model
601
Connection
602
603
Get preliminary storage info
604
605
Connection event
606
PM-store request
607
608
Get store meta-data
609
610
PM-store response
611
612
Get store data
613
614
Store segment data

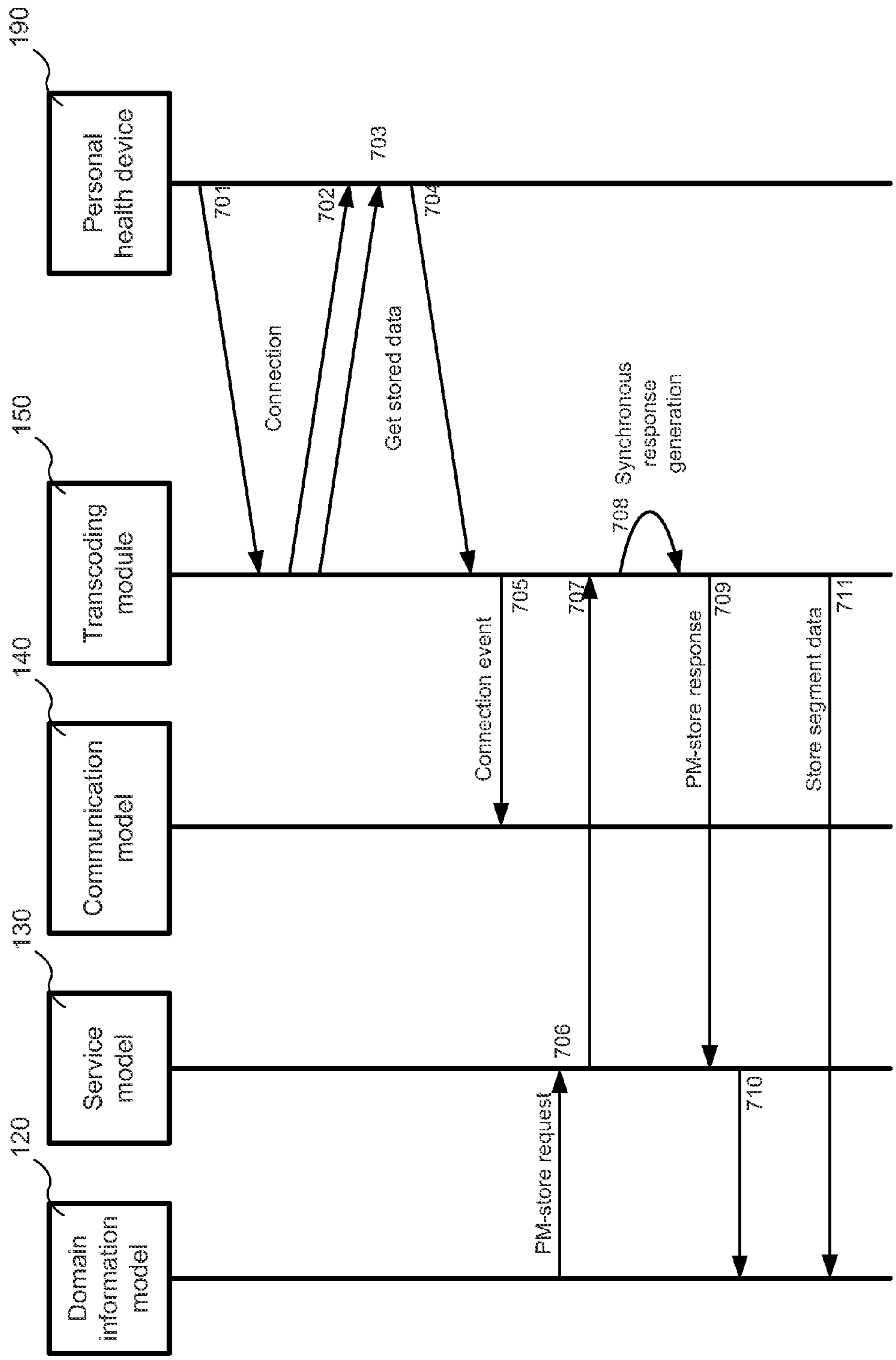
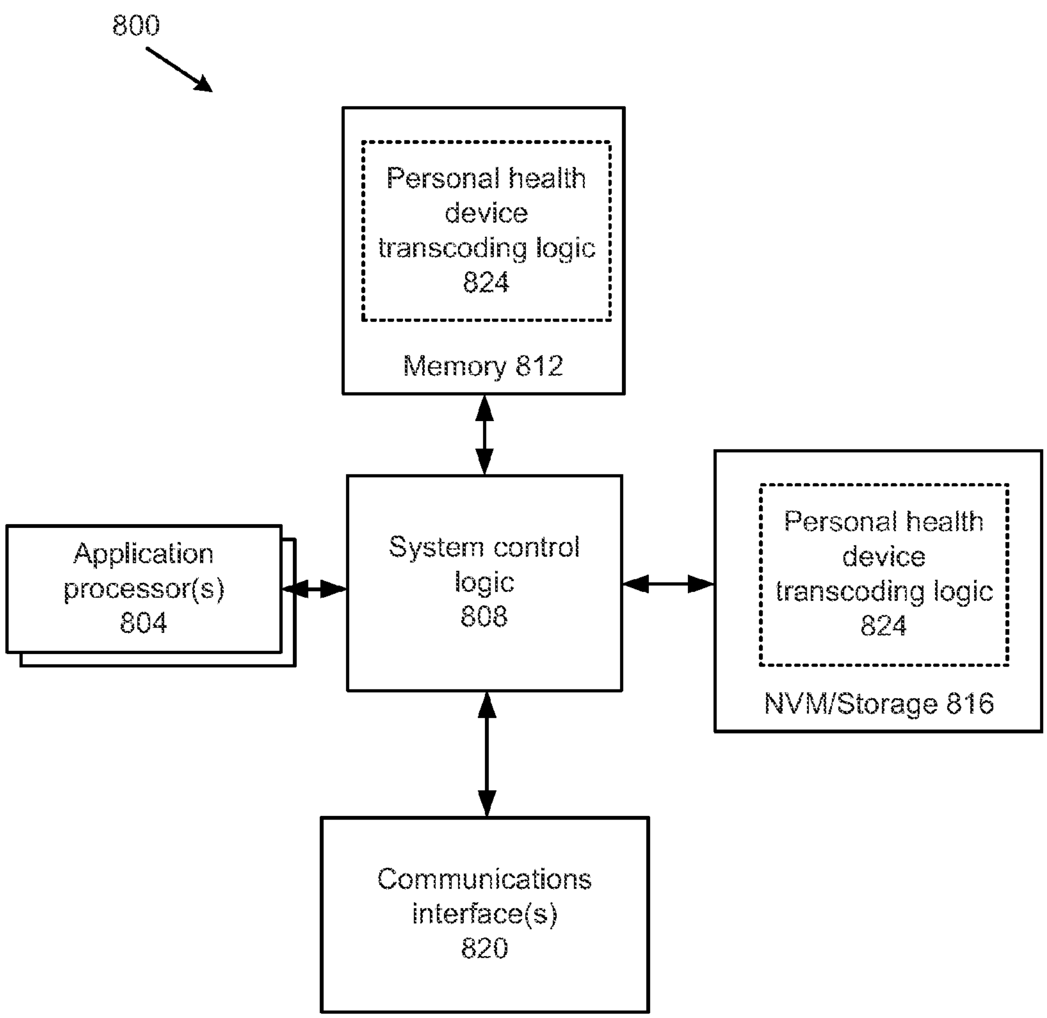

190
Personal health device
150
Transcoding module
140
Communication model
130
Service model
120
Domain information model
701
702
703
704
Connection
Get stored data
708
Synchronous response generation
705
Connection event
706
PM-store request
707
709
PM-store response
710
711
Store segment data

FIG. 7

Fig. 8


800
Personal health device transcoding logic 824
Memory 812
Application processor(s) 804
System control logic 808
Personal health device transcoding logic 824
NVM/Storage 816
Communications interface(s) 820

TRANSCODING OF COMMUNICATION WITH PERSONAL HEALTH DEVICES

BACKGROUND

Devices that communicate with each other, such as over a network, may often make use of interfaces or protocols that may define or describe types and/or formats of data that may be exchanged between the devices. One such set of interfaces may be defined by the IEEE 10703-20601 standard ("IEEE 11073"), which is a standard for personal health devices. Such devices may include, but are not limited to, for example, weighing scales, blood pressure measurement devices, glucose meters, heart rate monitors, etc. These devices may be employed in non-intensive care conditions, such as at a patient's home or while exercising. The standard describes a stack of protocols as well as roles taken by sensor and collector devices.

A personal health device, such as a sensor device, may take an agent role in IEEE 11073. A manager device may perform data collection activities in IEEE 11073. In various implementations, IEEE 11073 may put larger processing burden on manager devices, allowing agents typically to possess more limited processing power and/or lesser power requirements. Managers, by contrast may be executed in relatively more powerful apparatuses. These apparatuses may include various devices such as, but not limited to, mobile devices, cell phones, desktop computer, laptops computers, and/or servers.

However, there are many personal health devices in the market that do not follow IEEE 11073. There may be various reasons for this, including that some kinds of personal health devices simply cannot afford to fully implement an IEEE 11073 agent role. For example, some personal health devices may be expected to have a very long battery life or to be very simple in nature. This may lead to devices that have ultra-low power requirements, minuscule processing power, and/or severe restrictions on data transmission and reception.

In the other hand, IEEE 11073 may be increasingly important in the personal health devices market as larger numbers of compliant devices and managers are used. It may therefore be desirable to facilitate connection of non-IEEE 11073-compliant personal health devices to IEEE 11073 managers.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings.

FIG. **1** is a block diagram illustrating example components used in personal health device transcoding, in accordance with various embodiments.

FIG. **2** illustrates an example of components found in a transcoding module, in accordance with various embodiments.

FIG. **3** illustrates an example personal health device connection, configuration, and disconnection process, in accordance with various embodiments.

FIG. **4** illustrates example personal health device request and response processes, in accordance with various embodiments.

FIG. **5** illustrates example personal health device measurement data receipt processes, in accordance with various embodiments.

FIG. **6** illustrates an example personal health device stored data request and retrieval process, in accordance with various embodiments.

FIG. **7** illustrates another example personal health device stored data request and retrieval process, in accordance with various embodiments.

FIG. **8** illustrates an example computing environment suitable for practicing the disclosure, in accordance with various embodiments.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings which form a part hereof wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments is defined by the appended claims and their equivalents.

Various operations may be described as multiple discrete actions or operations in turn, in a manner that is most helpful in understanding the claimed subject matter. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order than the described embodiment. Various additional operations may be performed and/or described operations may be omitted in additional embodiments.

For the purposes of the present disclosure, the phrase "A and/or B" means (A), (B), or (A and B). For the purposes of the present disclosure, the phrase "A, B, and/or C" means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B and C).

The description may use the phrases "in an embodiment," or "in embodiments," which may each refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous.

As used herein, the term "module" may refer to, be part of, or include an Application Specific Integrated Circuit ("ASIC"), an electronic circuit, a processor (shared, dedicated, or group) and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

Referring now to FIG. **1**, a manager device **100** is shown according to various embodiments. In various embodiments, the various components and modules illustrated in FIG. **1** may be combined, broken into sub-components, and/or omitted entirely. The manager device **100** may communicate with a personal health device **190**, such as to control the personal health device **190** and/or to receive data from the personal health device **190**. In various embodiments, the communication may be performed via a communication channel **180**; the communication channel may include one of various wired and/or wireless communication channels, including Bluetooth™, WiFi, Ethernet, and/or RF channels.

In various embodiments, the manager device **100** may implement the IEEE 11073 standard. In various embodiments, the 11073 standard may specify various models that form a stack of protocols **115**, through which a manager application **110** may attempt to communicate with various personal health devices, such as personal health device **190**.

As illustrated, the manager device **100** may include a stack of three layered models: a communication model **120**, a service model **130**, and a domain information model **140**. In various embodiments, the models **120-140** may be implemented through different means, such as, for example, using software and/or hardware modules. In various embodiments, the models of the stack **115** may map roughly to an Open Systems Interconnection ("OSI") network model as follows: the communication model **140** may map to transport and presentation layers of an OSI model; the service model may map to a session layer of an OSI model; and the domain information model may maps to an application layer of an OSI model.

The manager device **100** may also include a transcoding module **150**. In various embodiments, the transcoding module **150** may be configured to facilitate communication between the manager device **100** (and specifically between the manager application **110**) and the personal health device **190**. In various embodiments, the transcoding module **150** may be configured to facilitate communications between the manager device **100** and the personal health device **190** even when the personal health device **190** does not implement IEEE 11073. Thus, in various embodiments, the transcoding module **150** may be configured to interact with the various models **120-140** of the stack **115** in order to redirect communications sent through the stack **115** and to emulate communication with the personal health device such that the device appears to implement IEEE 11073. In various embodiments, the transcoding module **150** may fill a role of collector/manager from the point of view of the personal health device **190** and may fill the role of an IEEE 11073 agent on behalf of the non-IEEE-11073-compliant personal health device **190**, from the point of view of the manager device **100**.

It may be noted that, while the transcoding module **150** is called a "transcoding module," this should not necessarily imply that in every embodiment the transcoding module **150** only performs transcoding of data received and sent to the personal health device **190**. In various embodiments, the transcoding module **150** may perform transcoding of data sent to or from the personal health device **190**. In other embodiments, however, the transcoding module **150** may emulate a communication as if the communication was received from the personal health device **190** without requiring that the personal health device **190** initiate the communication. Conversely, while the transcoding module **150** may be referred to as "emulating" communications between the manager device **100** and the personal health device **190**, in various embodiments, this should not imply that any or all communications sent through the transcoding module **150** are not based on actual communications sent to or from the personal health device **190**. In various embodiments, the transcoding module **150** may take actual data sent to or from the personal health device **190**, may perform transcoding on that data, and may send the transcoded data on, facilitating actual communications between the manager device **100** and the personal health device **190**.

In various embodiments, the transcoding module **150** may be configured to communicate in both "live" and "non-live" manners. Live transcoding may, in various embodiments, take place while the personal health device **190** is currently connected with the transcoding module **105** and while two-way, end-to-end communication between the manager device **100** and the personal health device **190** is possible. In various embodiments, the transcoding module may also be configured to perform non-live transcoding, which may store data from the personal health device **190** and then later make it available for the manager device **100**.

In various embodiments, the transcoding module may include a running IEEE 11073 stack, similar to stack **115**, that may take the role as an agent, and may communicate with the manager device **100** using its stack. In addition, the transcoding device may also include a second protocol stack that can communicate with the personal health device **190**, such as via a non-IEEE 11073 protocol that is understood by the personal health device **190**.

In various embodiments, however, the transcoding module **150** may be integrated into the implementation of the stack **115** of the manager device **100** such that the transcoding module **150** may avoid implementing an IEEE 11073 agent role.

Thus, in various embodiments, the transcoding module may implement the a protocol and state machine for the personal health device **190**, and may establish one-to-one relationships between native device events and IEEE 11073 events. The transcoding module **150** may be configured to feed such events directly into the models **120-140** of the stack **115**. Thus, as illustrated in FIG. **1**, rather than communicate solely with the lowest level of the stack **115** (e.g., the communication model **140**), the transcoding module **150** may communicate directly with various other models, such as the domain information model **120** and/or the service model **130**. Further, while in some IEEE 11073 implementations application packet data units ("APDU"s) are transmitted for communication between manager devices and personal health devices, in various embodiments, at the communication model **140** level, the transcoding module **150** may be configured such that the communication model **140** does not communicate or receive application packet data units to or from the transcoded devices. Instead, these application packet data units may be redirected before reaching the communication model **140**. In various embodiments, the transcoding module **150** may avoid the sending of APDUs because the transcoding module **150** may not operate as an IEEE 11073 agent. Thus, IEEE 11073 events that might result in the sending of an APDU may be rerouted by the transcoding module **150** for handling, such as described below. This rerouting may happen in different places of the stack **115** based on factors such as the event type.

In various embodiments, the transcoding module **150** may execute in the same device and/or processing unit other actions and modules of the manager device **110**. Thus, in various embodiments, the transcoding module **150** may live in the same host and process space as the manager application **110** and the stack **115**. The transcoding module may also shares memory with these components. In various embodiments, the transcoding module **150** may be implemented as a software plug-in, allowing easier and/or dynamic support addition to a new sensor devices model without changing the stack **115** itself. In various embodiments, manager device may include more than one transcoding module **150**, such as for various different personal health devices **190**. However, for the purposes of ease of illustration and description, only one transcoding module **150** and one personal health device **190** are shown and described.

Referring now to FIG. **2**, an example of components found in the transcoding module **150** is illustrated in accordance with various embodiments. As FIG. **2**, illustrates, in various embodiments, the transcoding module may include various modules which may communicate with the personal health device **190** or with various level of the stack **115** of the manager device **100**. In various embodiments, the various components and modules may be combined, broken into sub-components, and/or omitted entirely.

In various embodiments, the transcoding module **150** may communicate with the personal health device **190** through the device client state machine module **230**. In various embodiments, the device client state machine module **230** may implement a collector side of the non-IEEE 11073-compliant protocol which is supported by the personal health device **190**. In various embodiments, the device client state machine module **230** may also implement a state machine for the personal health device **190**. In various embodiments, the device client state machine module **230** may be the component of the transcoding module **150** that communicates directly with the personal health device **190**, while other modules communicate through the device client state machine module **230**.

The transcoding module **150** may also include a context manager **260**. In various embodiments, the context manager **260** may be configured to supply a connection context to the communication model **140** of the stack **115**. In various embodiments, the context provided by the context manager **260** may uniquely represent the physical health device **190**. In various embodiments, the context provided by the context manager **260** may be uniquely mapped to a unique system ID. In various embodiments, this unique mapping may facilitate the transcoding module **150** in allowing the stack **115** to handle both transcoded devices (e.g. the personal health device **190**) and non-transcoded devices in a similar fashion throughout the stack.

In various embodiments, the transcoding module may include an MDS object configuration module **210**. In various embodiments, the MDS object configuration module **210** may be configured to generate association and configuration information and to pass this information to the stack **115** such that the manager device **100** may create and populate a Medical Device System ("MDS") object to identify the personal health device and its status. The association and configuration information generated by the MDS object configuration module **210** may also identify one or more objects provided by the personal health device **190** to the manager device **100**. In various embodiments, the MDS object configuration module **210** may provide the association information directly to the domain information model **120**.

In various embodiments, the association information generated by the MDS object configuration module **210** may be based on actual information received from the personal health device **190** or may be generated entirely by the MDS object configuration module **210** without requiring information from the personal health device **190**. Implementations of processes for the transcoding module **150** to share association information with the manager device **100** are described below.

The transcoding module **150** may also include a measurement data transcoding module **220**, which may be configured, in various embodiments, to transcode measurement data received from the personal health device **190** by the device client state machine module **230** such that the data is compliant with IEEE 11073. In various embodiments, the measurement data transcoding module **220** may provide the association information directly to the domain information model **120**.

The transcoding module **150** may also comprise a synchronous service request handler module **240** and an asynchronous service request handler **250**. In various embodiments, these modules **240** and **250** may be configured to handle requests from, and to provide responses to, the service model **130** of the stack **115**. As illustrated, in various embodiments, the synchronous service request handler **240** may be configured to receive and responds to requests without communicating with the personal health device **190**. Also, as illustrated, in various embodiments, the asynchronous service request handler **250** may be configured to respond to requests by communicating with the personal health device **190** through the device client state machine module **230**. Particular examples of responding to requests are discussed below.

FIG. **3** illustrates an example personal health device connection, configuration, disconnection process, in accordance with various embodiments. In various embodiments, the actions illustrated in FIG. **3** may be performed by the transcoding module **150** in order to form a connection between the manager device **100** and the personal health device **190**, to provide association and configuration information to the manager device **100**, and later to end the connection. In various embodiments, the action described in FIG. **3** may be merged, divided into other actions, and/or reordered. The process may begin at operation **301**, where the transcoding module **150** may receive a connection request from the personal health device **190**; the transcoding module **150** may respond to that request at operation **302**, thus forming a connection between the transcoding module **150** and the personal health device **190**. As discussed above, in various embodiments, the connection may be made by the device client state machine module **260** of the transcoding module **150**, and communication between the personal health device **190** and the device client state machine module **260** may be performed using a protocol supported by the personal health device **190** and may be other than IEEE 11073. After establishment of the connection, then at operation **303** the transcoding module may sent a connection event to the communication model **140**, to establish to the communication model **140** of the stack **115** that a connection has been opened. It may be noted that other communications may be not be sent to the communication model **140**; instead, the communication model **140** may be bypassed in lieu of direct communication with the other models of the stack **115**.

After establishment of the connection, at operation **304** the transcoding module **150** may provide association information to the domain information model **120**. In various embodiments, the association information may be provide to the domain information model by the MDS object configuration module **210** of the transcoding module **150**. As illustrated, in various embodiments, this association information may be provided directly to the domain information model **120** and may bypass other models in the stack, such as the communication model **140** and the service model **130**. This association information may correspond to an IEEE 11073 association event. In various embodiments, the personal health device may not have a state similar to IEEE 11073 association; in such embodiments, the transcoding module **150** may generate the association information right after the connection event. This generation of the association information may thus be performed without communication with the personal health device **190**, in various embodiments. Alternatively, if the personal health device **190**'s state machine prescribes some kind of protocol handshake before it can send actual measurement data (or otherwise be communicated with), the transcoding module **150** may, in various embodiments, send association information after performing a handshake process with the personal health device **190**.

In various embodiments, at operation **304** the transcoding module may fill an IEEE 11073 PhdAssociationInformation structure and may pass it to the domain information module **120** of the stack **115**. In various embodiments, the use of the PhdAssociationInformation may provide a balance between complexity in the transcoding module **150** and in adding complexity to the stack **115**. It may be noted that the PhdAssociationInformation may be received in some IEEE 11073 managers in an association APDU. By using similar structures, various embodiments, may keep reduce distinctions between transcoded and non-transcoded devices from the perspective of the manager device **100**.

In various IEEE 11073 manager device implementations, after receiving association information, an IEEE 11073 Manager may go from a "disassociated" to an "operating" state if a configuration for an IEEE 11073 Agent is already known. Otherwise, in IEEE 11073 implementations, the IEEE 11073 Manager may go to an "associated" state and may inform the associated IEEE 11073 Agent configuration information for the associated IEEE 11073 Agent (identified by information in the PhdAssociationInformation) is unknown. The IEEE 11073 Agent device is then be expected to send a ConfigReport APDU. Once the IEEE 11703 Manager receives the configuration and approves it, MDS objects may be created in the IEEE 11073 Manager's memory.

Thus, in order to provide interoperability with the personal health device **190**, in various embodiments, at operation **305**, the transcoding module **150** may provide configuration information to the domain information module **120**. In various embodiments the provision of the configuration information may be provided after the stack **115** of the manager device **100** notifies the transcoding module **150** that the identified configuration is unknown. Thus, in various embodiments, the transcoding module **150**, may fill a ConfigReport structure and send it to the domain information model **120** of the stack **115**. This provisioning of the configuration information may be provided, in various embodiments, by the MDS object configuration module **210** of the transcoding module **150**.

In various embodiments, the ConfigReport structure may be generated locally by the transcoding module **150** and may be generated with a higher likelihood of being error-free. Therefore, in various embodiments, the transcoding module **150** may assume that the stack **115** will not reject the configuration; the transcoding module **150** may therefore not receive (or expect) any further feedback. The transcoding module **150** may therefore operate under the assumption that, after the configuration information is provided, that the current context for the personal health device **190** is an "operating" state.

In various embodiments, at operation **306**, MDS attributes in the domain information module **120** of the stack **115** may then be filled by the transcoding module **150**. In various embodiments, the transcoding module **150** may fill the MDS attributes by directly writing to/changing an MDS structure in the domain information model **120** of the stack **115** of the manager device **100**. In various embodiments, the transcoding module **150** may fill in the attributes without performing APDU encoding or a service request. In various embodiments, the filling of the MDS attributes may be performed by the MDS object configuration module **210** of the transcoding module **150**. In various embodiments, attributes described in IEEE 11073 may be fulfilled. In some embodiments, all attributes that are mandated by IEEE 11073 may be filled, even those attributes that are not mapped to any feature in the personal health device **190**.

In various embodiments, a disconnection of the personal health device **190** may also be facilitated by the transcoding module **150**. Thus, at operation **307**, the personal health device may send a disconnection notice to the transcoding module **150**, and may receive an acknowledgement from the transcoding module **150**. The transcoding module **150** may then generate an disassociation event for the connection context and send this to the communication model **140** of the stack **115**. In various embodiments, if the personal health device **190** does not have a state similar to IEEE 11073 disassociation, the transcoding module may generate the disassociation event at operation **309** right before the disconnection with the personal health device **190**. The process may then end.

FIG. **4** illustrates example personal health device request and response processes, in accordance with various embodiments. In various embodiments, the actions illustrated in FIG. **4** may be performed by the transcoding module **150** in order to facilitate requests and responses between the manager device **100** and the personal health device **190**. In various embodiments, the action described in FIG. **4** may be merged, divided into other actions, and/or reordered.

In various embodiments, the transcoding module **150** may provide service model-level transcoding with the personal health device **190**. In various embodiments, requests from the manager device **100** to the personal health device **190** (serving the IEEE 11073 Agent role) are partially handled as IEEE 11073 service requests within the stack **115**. However, in various embodiments, the service model **130** may be configured to distinguish between transcoded devices and devices that implement the IEEE 11073 Agent role on their own. The service model **130** may be configured to thereby reroute requests received from the domain information model **120** to the transcoding module instead of generating a remote operation invoke request APDU and sending the request to the communication model **140**. In other embodiments, the service model may not distinguish between transcoded and non-transcoded devices. In some such embodiments, the transcoding module **150** may be configured to redirect a remote operation invoke request APDU generated by the service model without the service model **130** being aware of the transcoding module's interception.

In various embodiments, requests from the manager device **100** may be distinguished into two subtypes: synchronous and asynchronous. In various embodiments, synchronous requests may be fulfilled within the transcoding module **150**, without need of communication with the personal health device **190**. Thus, a synchronous request and response process may begin at operation **401**, where, in various embodiments, the domain information model **120** may send a request to the service model **130**. Next, at operation **402**, in various embodiments the service model **130** may send the request to the transcoding module. At operation **403**, in various embodiments the transcoding module **150** may generate a response locally without communicating with the personal health device **190**. At operation **404**, the locally-generated response may then, in various embodiments, be sent to the service model **130**, and the service model **130** may send the response to the domain information model **120** at operation **405**. The process may then end.

By contrast with synchronous requests, in various embodiments asynchronous requests may change the state of the state machine of the personal health device **190**. The asynchronous response may, in various embodiments, be received from the personal health device **190** and then transcoded back to the service model **130**. In various embodiments, the transcoding module **150** may be configured to keep track of the personal health device **190** and to notify the service model **130** with a negative response in case of failure. In various embodiments, the service model **130** may be configured to provide a hook for the transcoding module **150** to send positive or negative responses.

An asynchronous request and response process may begin at operation **406**, where, in various embodiments, the domain information model **120** may send a request to the service model **130**. Next, at operation **407**, in various embodiments the service model **130** may send the request to the transcoding module. At operations **408** and **409**, in various embodiments the transcoding module **150** may send the request to the personal health device **190** and may receive a response from the personal health device **190**. At operation **410**, the received response may then, in various embodiments, be sent to the service model **130**, and the service model **130** may send the response to the domain information model **120** at operation **411**. The process may then end.

In various embodiments, methods of classifying requests from the manager device **100** as synchronous or asynchronous may vary. In various embodiments, the manner of classification may vary based on the sets of features provided by various personal health devices **190**, which may be mapped to MDS attributes in different ways. In one example, a transcoding module **150** may be configured to interoperate with a relatively simple personal health device **190** that is configured only to send measurement values using, for example, a simplex protocol. Such a transcoding module may be configured to handle service requests synchronously.

In various embodiments, the transcoding module **150** may be configured to handle Get and Set operation requests on MDS attributes from the stack **115** of the manager device **100**. In various embodiments, the Get and Set operation requests may be handled synchronously or asynchronously based on, for example, capabilities of the personal health device **190** as well as whether these capabilities can be mapped to MDS attributes.

In various embodiments, a Set-Time operation request may be transcoded in an analog way. Thus, the transcoding module may, in various embodiments, fill relevant MDS attributes accordingly to Set-Time support. In various embodiments, the Set-Time operation request may be supported when the personal health device **190** has an internal and resettable clock. In other embodiments, the transcoder module **150** may be configured to maintain a clock separate from the manager device **100**. Thus, measurement timestamping may be supported in various ways.

In various embodiments, requests from the personal health device to the manager device may not be transcoded as IEEE 11073 service requests. Instead, these requests may be fed directly and synchronously into the domain information model **120** (not illustrated). For example, as discussed above, during configuration, MDS attributes (such as, for example, supplied by the MDS object configuration component **210** of the transcoding module **150**) may be provided directly to the domain information model **120**. In other examples, in various embodiments, measurement data and store segment data (both supplied by measurement transcoding module) may be provided directly to the domain information model.

FIG. **5** illustrates example personal health device measurement data receipt processes, in accordance with various embodiments. In various embodiments, the actions illustrated in FIG. **5** may be performed by the transcoding module **150** and other actors in order to facilitate receipt of measurement data from the personal health device **190** by the manager device **100**. In various embodiments, the action described in FIG. **5** may be merged, divided into other actions, and/or reordered.

In various embodiments, when measurement data comes from the personal health device, it may be transcoded and packaged in a suitable structure (such as, for example, ScanReportInfoFixed, SpanReportInfoVar, ScanReportInfoMPFixed, etc.). The transcoded and packaged measurement data may then be sent directly to the domain information model **120** of the stack **115**. In various embodiments, the service model **130** may be bypassed.

In various embodiments, the transcoding module **150** may or may not confirm receipt of measurement data, such as through sending a acknowledgement to the personal health device **190**. In various embodiments, the transcoding module **150** may send the acknowledgement based at least in part on whether and acknowledgement is expected by the personal health device **190**.

Thus, in various embodiments, a measurement receipt process may begin at operation **501**, where measurement data may be received from the personal health device **190**. At operation **502**, in various embodiments, the transcoding module **150** may confirm receipt of the measurement data by sending an acknowledgement back to the personal health device **190**. As illustrated in FIG. **5**, this acknowledgement may be performed before delivering the measurement data to the stack **115**. Next, the transcoding module **150** may transcode the received measurement data at operation **503** and may deliver the transcoded data at operation **504**. By contrast, operations **505**, **506**, and **507** illustrate similar actions performed when the personal health device does not require confirmation of measurement data receipt. Thus, at operation **505**, measurement data may be received from the personal health device **190**. Next, the transcoding module **150** may transcode the received measurement data at operation **506** and may deliver the transcoded data at operation **507**. The process may then end.

In various embodiments, the personal health device **190** may be capable of storing measurements for later retrieval by the manager device **100**. In various embodiments, the transcoding module **150** may be configured to transcode the stored data, which may allow the manager device **100** to access the stored measurement data using IEEE 11073 PM-Store service requests even if the personal health device **190** does not itself support such requests. In various embodiments, the transcoding module **150** may choose between two strategies regarding the store: 1) fetch on demand (asynchronously), or 2) fetch all stored data upon connection.

FIG. **6** illustrates an example personal health device stored data request and retrieval process, in accordance with various embodiments. In various embodiments, actions illustrated in FIG. **6** may be performed by the transcoding module **150** and other actors in order to facilitate an asynchronous retrieval of measurement data stored by the personal health device **190** by the manager device **100**. In various embodiments, the action described in FIG. **6** may be merged, divided into other actions, and/or reordered.

The process may begin at operations **601** and **602**, where, in various embodiments, a connection request may be received by the transcoding module from the personal health device **190** and the transcoding module **150** may establish the connection. Then, at operation **603**, the transcoding module **150** may send a request to get preliminary storage info for the personal health device **190** and may receive preliminary storage information at operation **604**. In various embodiments, the preliminary storage information may contain information about whether the personal health device **190** has storage capabilities and what type of storage it may perform. The request for and receipt of preliminary storage information may, in various embodiments, be performed before establishment of a connection for the personal health device **190** between the transcoding module **150** and the stack **115**. Thus, at operation **605**, the transcoding module **150** may then send a connection event to the communication model **140**.

Next, at operation **606**, in various embodiments, the domain information model **120** may send a PM-store Get request to the service model **130**. At operation **607**, the PM-store Get request may be intercepted by the transcoding module **150**. Similarly to the discussion above, in various embodiments, the service model **130** may be configured to send the request to the transcoding module **150**; in other embodiments, the transcoding module may intercept a request sent by the service model **130** to the communication model **140**.

Next, at operation **608**, the transcoding module **150** may get meta-data describing the store data that is to be sent from the personal storage device. In various embodiments, the transcoding module **150** may, at operation **608**, transcode a GetSegmentInfo request from the stack **115**, such as described above in the Set operation. In various embodiments, at operation **609** the personal health device **190** may respond with meta-data and/or summarized information for its stored data. The transcoding module **150** may then, at operation **610**, provide a PM-store response to the service model **130**, which may be sent to the domain information model at operation **611**. In various embodiments, in the case of failure or receipt of bad parameters from the personal health device, a negative response may be provided to the stack **115** by the transcoding module **150**.

Next, at operation **612**, the transcoding module **150** may get stored data from the personal health device **190**. In various embodiments, the transcoding module may be configured to transcode a TrigSegmDataXferReq request from the stack **115** to a data transfer request that may be understood by the personal health device **190**, such as under similar guidelines as the Set operation. In various embodiments, the transcoding module may be configured to transcode the segment selection, and may provide a negative response in case of failure or bad parameters.

In various embodiments, at operation **613**, the transcoding module **150** may receive segment data from the personal health device **190**. Then, at operation **614**, the transcoding module **150** may send segment data received by the transcoding module directly to the domain information model **120**. In various embodiments, the transcoding module **150** may utilize the measurement data transcoding module **220** to encode and pass the information as a SegmentDataEvent structure. The process may then end.

FIG. **7** illustrates a second example personal health device stored data request and retrieval process, in accordance with various embodiments. In various embodiments, actions illustrated in FIG. **7** may be performed by the transcoding module **150** and other actors in order to facilitate a synchronous retrieval of measurement data stored by the personal health device **190** by the manager device **100**. In various embodiments, the action described in FIG. **7** may be merged, divided into other actions, and/or reordered.

The process may begin at operations **701** and **702**, where, in various embodiments, a connection request may be received by the transcoding module from the personal health device **190** and the transcoding module **150** may establish the connection. Next, at operation **703**, the transcoding module **150** may get stored data from the personal health device **190**, and may receive the stored data at operation **704**. In various embodiments, the transcoding module **150** may retrieve all or part of the data stored by the personal health device **190**. In various embodiments, the stored data may be received prior to receipt of a PM-store request by the transcoding module **150**; indeed, the transcoding module **150** may retrieve the stored data before even reporting a connection event to the stack **115**. Thus, at operation **705**, in various embodiments, the transcoding module **150** may send a connection event to the communication model **140** after retrieving the stored data from the personal health device **190**.

Next, at operation **706**, in various embodiments, the domain information model **120** may send a PM-store request to the service model **130**. At operation **707**, the PM-store request may be intercepted by the transcoding module **150**. Similarly to the discussion above, in various embodiments, the service model **130** may be configured to send the request to the transcoding module **150**; in other embodiments, the transcoding module may intercept a request sent by the service model **130** to the communication model **140**.

At operation **708**, the transcoding module **150** may generate a synchronous response using the previously-retrieved data from the personal health device **190**. In various embodiments, the generation of the response may be done without further communication between the transcoding module **150** and the personal health device **190**. The transcoding module **150** may then, at operation **709**, provide a PM-store response to the service model **130**, which may be sent to the domain information model at operation **710**. In various embodiments, in the case of failure or receipt of bad parameters from the personal health device, a negative response may be provided to the stack **115** by the transcoding module **150**. Then, at operation **711**, the transcoding module **150** may send segment data retrieved by the transcoding module directly to the domain information model **120**. In various embodiments, the transcoding module **150** may utilize the measurement data transcoding module **220** to encode and pass the information as a SegmentDataEvent structure. The process may then end.

FIG. **8** illustrates, for one embodiment, an example computer system **800** suitable for practicing embodiments of the present disclosure. As illustrated, example computer system **800** may include control logic **808** coupled to at least one of the processor(s) **804**, system memory **812** coupled to system control logic **808**, non-volatile memory (NVM)/storage **816** coupled to system control logic **808**, and one or more communications interface(s) **820** coupled to system control logic **808**. In various embodiments, the one or more processors **804** may be a processor core.

System control logic **808** for one embodiment may include any suitable interface controllers to provide for any suitable interface to at least one of the processor(s) **804** and/or to any suitable device or component in communication with system control logic **808**.

System control logic **808** for one embodiment may include one or more memory controller(s) to provide an interface to system memory **812**. System memory **812** may be used to load and store data and/or instructions, for example, for system **800**. In one embodiment, system memory **812** may include any suitable volatile memory, such as suitable dynamic random access memory ("DRAM"), for example.

System control logic **808**, in one embodiment, may include one or more input/output ("I/O") controller(s) to provide an interface to NVM/storage **816** and communications interface(s) **820**.

NVM/storage **816** may be used to store data and/or instructions, for example. NVM/storage **816** may include any suitable non-volatile memory, such as flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) ("HDD(s)"), one or more solid-state drive(s), one or more compact disc ("CD") drive(s), and/or one or more digital versatile disc ("DVD") drive(s), for example.

The NVM/storage **816** may include a storage resource physically part of a device on which the system **800** is installed or it may be accessible by, but not necessarily a part of, the device. For example, the NVM/storage **816** may be accessed over a network via the communications interface(s) **820**.

System memory **812** and NVM/storage **816** may include, in particular, temporal and persistent copies of personal health device transcoding logic **824**. The personal health device transcoding logic **824** may include instructions that when executed by at least one of the processor(s) **804** result in the system **800** practicing one or more of the operations described above for the transcoding module **150**. In some embodiments, the personal health device transcoding logic **824** may additionally/alternatively be located in the system control logic **808**.

Communications interface(s) **820** may provide an interface for system **800** to communicate over one or more network(s) and/or with any other suitable device. Communications interface(s) **820** may include any suitable hardware and/or firmware, such as a network adapter, one or more antennas, a wireless interface, and so forth. In various embodiments, communication interface(s) **820** may include an interface for system **800** to use NFC, optical communications (e.g., barcodes), Bluetooth or other similar technologies to communicate directly (e.g., without an intermediary) with another device.

For one embodiment, at least one of the processor(s) **804** may be packaged together with system control logic **808** and/or personal health device transcoding logic **824** (in whole or in part). For one embodiment, at least one of the processor(s) **804** may be packaged together with system control logic **808** and/or personal health device transcoding logic **824** (in whole or in part) to form a System in Package ("SiP"). For one embodiment, at least one of the processor(s) **804** may be integrated on the same die with system control logic **808** and/or personal health device transcoding logic **824** (in whole or in part). For one embodiment, at least one of the processor(s) **804** may be integrated on the same die with system control logic **808** and/or personal health device transcoding logic **824** (in whole or in part) to form a System on Chip ("SoC").

In various embodiments, a computer-implemented method may facilitate communications between a personal health device and a manager device, which may be configured to implement a stack of health information protocols. The method may include redirecting, by a transcoding module executing on a computing device, a communication to be sent between the manager device and the personal health device via the stack of health information protocols, such that the communication is not sent through the entire stack of health information protocols. The method may also include emulating, by the transcoding module, transmission of the communication to the personal health device. The method may also include emulating, by the transcoding module, transmission of one or more responses from the personal health device to the manager device such that the one or more responses appear, to the manager device, to be generated by the personal health device through implementing the stack of health information protocols.

In various embodiments, the transcoding module may be executed on the manager device and redirecting the communication may include redirecting the communication before it is sent outside of the manager device. In various embodiments, the stack of health information protocols may include an IEEE 11073-20601 standard stack (IEEE stack) and the manager device may include an IEEE 11073-20601-compliant manager device.

In various embodiments, emulating transmission of one or more responses may include providing the one or more responses directly into the IEEE stack at a domain information model level or a service model level. In various embodiments, redirecting the communication may include: redirecting the communication from the IEEE stack at a domain information model level or a service model level, transcoding the redirected communication such that it may be understood by the personal health device, and transmitting the transcoded communication to the personal health device via a communication channel.

In various embodiments, wherein emulating transmission of one or more responses may include generating information, by the transcoding module, that appears to the manager device to be generated by the personal health device through implementation of the IEEE stack and providing, by the transcoding module, the generated information to the IEEE stack.

In various embodiments, generating information may include generating a IEEE 11073-20601 standard-compliant medical device system object describing the personal health device. In various embodiments, generating information may include generating an IEEE 11073-20601 standard-compliant connection event and providing the generated information comprises providing the connection event to a communication model of the IEEE stack. In various embodiments, generating information may include: receiving information generated by the personal health device and transcoding the received information such that the transcoded information appears to be generated through implementation of the IEEE stack by the personal health device.

In various embodiments, emulating transmission of one or more responses may include: requesting information from the personal health device prior to a request of the information from the IEEE stack, storing the requested information, and in response to a subsequent request for the information, providing the stored information to the IEEE stack.

In various embodiments, the method may further include communicating with the personal health device via a protocol that is other than the stack of health information protocols.

In various embodiments, an IEEE 11073-20601 standard-compliant manager device may include one or more computer processors. The manager device may also include one or more stack modules configured to be operated on the one or more computer processors to implement a IEEE 11073-20601 standard stack (IEEE stack) to communicate with a personal health device that implements the IEEE 11073-20601 standard stack. The manager device may also include a transcoder module configured to be operated on the one or more computer processors. The transcoder module may be configured to redirect a communication to be sent through the IEEE stack from the manager device to a personal health device such that the communication is not sent through the entire IEEE stack. The transcoder module may also be configured to emulate transmission of the communication to the personal health device. The transcoder module may also be configured to emulate transmission of one or more responses from the personal health device to the IEEE stack such that the personal health device appears to implement the IEEE stack.

In various embodiments, the transcoder module may be configured to redirect the communication and to emulate transmission of one or more responses directly with the IEEE stack at a domain information model level or a service model level.

In various embodiments, emulate transmission of one or more responses may include generate information that appears to be generated by the personal health device through implementation of an IEEE stack at the personal health device and provide the generated information to the IEEE stack at the manager device.

In various embodiments, generate information may include generate an IEEE 11073-20601 standard-compliant medical device system object describing the personal health device or an IEEE 11073-20601 standard-compliant connection event. In various embodiments, generate information may include receive information generated by the personal health device and transcode the received information such that the transcoded information appears to be generated through implementation of an IEEE stack at the personal health device.

Computer-readable media (including non-transitory computer-readable media), methods, apparatuses, systems and devices for performing the above-described techniques are illustrative examples of embodiments disclosed herein. Additionally, other devices in the above-described interactions may be configured to perform various disclosed techniques.

Although certain embodiments have been illustrated and described herein for purposes of description, a wide variety of alternate and/or equivalent embodiments or implementations calculated to achieve the same purposes may be substituted for the embodiments shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims.

Where the disclosure recites "a" or "a first" element or the equivalent thereof, such disclosure includes one or more such elements, neither requiring nor excluding two or more such elements. Further, ordinal indicators (e.g., first, second or third) for identified elements are used to distinguish between the elements, and do not indicate or imply a required or limited number of such elements, nor do they indicate a particular position or order of such elements unless otherwise specifically stated.

What is claimed is:

1. A computer-implemented method for facilitating communications between a personal health device and a manager device, the manager device configured to implement a stack of health information protocols and the personal health device configured to communicate utilizing communications other than the stack of health information protocols, the method comprising;

redirecting, by a transcoding module executing on a computing device, a communication to be sent between the manager device and the personal health device via the stack of health information protocols, such that the communication is redirected prior to being sent through the entire stack of health information protocols from the manager device;

emulating, by the transcoding module, transmission of the communication to the personal health device, the emulating causing the communication to appear as if the communication were sent through the stack of health information protocols; and

emulating, by the transcoding module, transmission of one or more responses from the personal health device to the manager device such that the one or more responses appear, to the manager device, to be generated by the personal health device implementing the stack of health information protocols.

2. The method of claim **1**, wherein:

the transcoding module is executed on the manager device; and

redirecting the communication comprises redirecting the communication before it is sent outside of the manager device.

3. The method of claim **1**, wherein:

the stack of health information protocols comprises an IEEE 11073-20601 standard stack (IEEE stack); and

the manager device comprises an IEEE 11073-20601-compliant manager device.

4. The method of claim **3**, wherein emulating transmission of one or more responses comprises providing the one or more responses directly into the IEEE stack at a domain information model level or a service model level.

5. The method of claim **3**, wherein redirecting the communication comprises:

redirecting the communication from the IEEE stack at a domain information model level or a service model level;

transcoding the redirected communication such that it may be understood by the personal health device; and

transmitting the transcoded communication to the personal health device via a communication channel.

6. The method of claim **3**, wherein emulating transmission of one or more responses comprises:

generating information, by the transcoding module, that appears to the manager device to be generated by the personal health device through implementation of the IEEE stack; and

providing, by the transcoding module, the generated information to the IEEE stack.

7. The method of claim **6**, wherein generating information comprises generating a IEEE 11073-20601 standard-compliant medical device system object describing the personal health device.

8. The method of claim **6**, wherein generating information comprises generating an IEEE 11073-20601 standard-compliant connection event and providing the generated information comprises providing the connection event to a communication model of the IEEE stack.

9. The method of claim **6**, wherein generating information comprises:

receiving information generated by the personal health device; and

transcoding the received information such that the transcoded information appears to be generated through implementation of the IEEE stack by the personal health device.

10. The method of claim **3**, wherein emulating transmission of one or more responses comprises:

requesting information from the personal health device prior to a request of the information from the IEEE stack;

storing the requested information; and

in response to a subsequent request for the information, providing the stored information to the IEEE stack.

11. The method of claim **1**, further comprising communicating with the personal health device via a protocol that is other than the stack of health information protocols.

12. An IEEE 11073-20601 standard-compliant manager device, comprising:

one or more computer processors;

one or more stack modules configured to be operated on the one or more computer processors to implement a IEEE 11073-20601 standard stack (IEEE stack) to communicate with a personal health device that does not implement the IEEE 11073-20601 standard stack; and

a transcoder module configured to be operated on the one or more computer processors to:

redirect a communication to be sent through the IEEE stack from the manager device to a personal health device such that the communication is redirected prior to being sent through the entire IEEE stack from the manager device;

emulate transmission of the communication to the personal health device, such that the communication appears as if the communication were sent through the IEEE stack; and emulate transmission of one or more responses from the personal health device to the IEEE stack such that the personal health device appears to implement the IEEE stack.

13. The device of claim **12**, wherein the transcoder module is configured to redirect the communication and to emulate transmission of one or more responses directly with the IEEE stack at a domain information model level or a service model level.

14. The device of claim **12**, wherein emulate transmission of one or more responses comprises:

generate information that appears to be generated by the personal health device through implementation of an IEEE stack at the personal health device; and

provide the generated information to the IEEE stack at the manager device.

15. The device of claim **14**, wherein generate information comprises generate an IEEE 11073-20601 standard-compliant medical device system object describing the personal health device or an IEEE 11073-20601 standard-compliant connection event.

16. The device of claim **14**, wherein generate information comprises:

receive information generated by the personal health device; and

transcode the received information such that the transcoded information appears to be generated through implementation of an IEEE stack at the personal health device.

17. One or more non-transitory computer-readable media comprising instructions stored thereon that are configured to be executed on a manager computing device that implements a IEEE 11073-20601 standard stack (IEEE stack), wherein the instructions are configured to cause the manager device, in response to execution of the instructions, to:

redirect a communication to be sent through the IEEE stack from the manager device to a personal health device such that the communication is redirected prior to being sent through the entire IEEE stack from the manager computing device;

emulate transmission of the communication to the personal health device such that the communication appears as if the communication were sent through the IEEE stack; and

emulate transmission of one or more responses from the personal health device to the IEEE stack such that the personal health device appears to implement the IEEE stack.

18. The non-transitory computer-readable media of claim **17**, wherein the instructions are configured to cause the manager device to redirect the communication and to emulate transmission of one or more responses directly with the IEEE stack at a domain information model level or a service model level.

19. The non-transitory computer-readable media of claim **17**, wherein the instructions are configured to emulate transmission of one or more responses through:

generation of information that appears to be generated by the personal health device through implementation of an IEEE stack at the personal health device; and

provision of the generated information to the IEEE stack at the manager device.

20. The non-transitory computer-readable media of claim **19**, wherein generation of information comprises generation of an IEEE 11073-20601 standard-compliant medical device system object describing the personal health device or an IEEE 11073-20601 standard-compliant connection event.

21. The non-transitory computer-readable media of claim **19**, wherein generation of information comprises:

receipt of information generated by the personal health device; and

transcode of the received information such that the transcoded information appears to be generated through implementation of an IEEE stack at the personal health device.

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